PATENT SPECIFICATION (11) 1 523 599

1 523 599

(21) Application No. 41927/75 (22) Filed 14 Oct. 1975

(31) Convention Application No. 2 449 395 (32) Filed 17 Oct. 1974 in

(33) Fed. Rep. of Germany (DE)

(44) Complete Specification published 6 Sept. 1978

(51) INT. CL.² H02P 7/18 // 7/28

(52) Index at acceptance

H2J 12C 12D 12N1 12N3B 12N3Y 12NX 2C 2G6A 2G6C1 2G6CY 2J2 7A 7C

(54) IMPROVEMENTS IN OR RELATING TO ELECTRIC MOTOR CONTROL CIRCUITS

(71) We, STILL GMBH (formerly SE FAHRZEUGWERKE GMBH), a German Company of 2 Hamburg 74, Berzeliustrasse, German Federal Republic, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to electric motor control circuits for switching over the direction of rotation of electric motors provided with a regulating device for the current flow, and especially to circuits for vehicles such as earth conveying vehicles and fork-lift trucks, where two movement direction contactors are provided, each assigned to one movement direction, and which are selectively operated by means of a movement direction change-over switch. In vehicles with pulse-controlled d.c. motors, it is known to employ a movement direction change-over switch to set the direction of rotation of the electric motor, together with a speed controller element which emits a control signal to the pulse control unit. The setting of the speed controller element is generally controlled by pedals. If the movement direction change-over switch is controlled by the same pedals, a purely mechanical coupling is possible, as the movement direction switch can be such that it can only be switched over when the mechanical part of the speed controller element is set at zero. A mechanical coupling of this kind is difficult when the movement direction change-over switch is manually operated, as it is then arranged at some considerable distance from the speed controller element. If the movement direction switch is independent of the speed controller element, it is possible to operate the movement direction change-over switch at a time when a high current is flowing through the motor, for example, in order to facilitate a rapid change in movement direction of a fork-lift truck. However, this not only produces a violent impact in the drive system, but also gives rise to electrical arcs, and thus to a burning of the contacts through which the motor current flows.

The invention consists in a d.c. motor control apparatus for an electrically propelled vehicle, comprising a speed controller for regulating the current supplied to the motor, first and second contactors respectively actuable, in use, to complete connections to the motor windings for rotation of the motor in first and second directions corresponding to forward and reverse motion of the vehicle, switching means selectively operable to pass an actuating current to one or other of the contactor coils, and disabling means including current sensing means connected in series with said switching means for sensing the flow of said actuating current, said disabling means being arranged to inhibit the supply of motor current by the speed controller when the actuating current is interrupted so that, in use, supply of the motor current is at least substantially reduced before opening of the motor circuit by the relevant contactor.

This arrangement ensures that, when reversing takes place, and either one of the pair of contactors is switched off, a signal for the disconnection of the motor current supply is emitted, so that the current is at least substantially reduced before the contacts open. Preferably the supply is not reconnected until the other contactor has been switched on. A particularly expedient use is for pulse controlled d.c. motors used in vehicles such as earth-moving vehicles and fork-lift trucks.

Preferably the disabling means includes a current sensing resistor which is connected, e.g. via a limiting resistor, between

the base and emitter of a control transistor whose collector is connected via a control path to the speed controller. This results in the fact that whenever the resistor is not traversed by current, because no current is flowing through either contactor coil, there is no voltage drop across the resistor and the control transistor becomes non-conductive, and a corresponding signal is fed to the speed controller to inhibit the supply of motor current thereby.

Preferably, the speed controller has an input connectable to receive a control voltage from control means adjustable by the operator and said control path includes, an inverter and a series blocking diode arranged between the collector of the transistor and the controller input. A capacitor may be connected to said input, the capacitor being discharged via the diode and the inverter when the transistor is non-conductive, the speed controller input voltage being unaffected when the transistor is conductive.

In a preferred embodiment the apparatus includes a signal source controllable by the vehicle operator to provide at an output thereof a variable control signal, the speed controller being connected to receive said control signal and arranged in operation to control the motor current in accordance with the control signal, and a semiconductor switching element connected in series with said switching means, and so controlled by the control signal that the switching element is non-conductive or conductive whenever the control signal is respectively below or above a predetermined level which corresponds to substantially zero motor drive by the speed controller (an arrangement of this type is the subject of our co-pending U.K. Patent Application No. 41928/75 (Serial No. 1523600).

Preferably, the semiconductor switching element is a transistor whose base is connected via a control path to said output of the signal source, so that a circuit is constructed which has no moving parts, and is thus wear-free. Advantageously the path from the input signal line to the transistor may contain a comparator so that the transistor switches on only when the signal from the source exceeds a limit value, and/or a logic linking gate through which the opening of the interrupter transistor can be made dependent upon other conditions, for example the signal of a temperature-sensitive switch that monitors the motor temperature.

An exemplary embodiment of the invention will now be described with reference to the accompanying drawing, which is a schematic diagram of a d.c. motor control apparatus.

A d.c. motor which is to be controlled possesses an armature 20 and a field winding 21, which can be selectively connected in series between supply lines 22 and 23 via contacts 24 and 25 for one direction of rotation, or via contacts 26 and 27 for the other direction of rotation.

The contacts 24 and 25 are closed when a first contactor coil 16 is traversed by current, and the contacts 26 and 27 are closed when a second contactor coil 17 is traversed by current. An arbitrarily operable movement direction change-over switch 13 determines which of the contactor coils 16 or 17 can be traversed by the current.

For the regulation of current flow through the motor windings 20 and 21 to control the speed of the motor, a pulse control unit is provided, comprising a voltage-frequency converter 9 and a thyristor switching element 14.

This pulse control unit is controlled from a speed controller voltage generator 1, which in this embodiment is a potentiometer or a differential field plate resistor, and which supplies an input signal to a line 28 which leads via resistors 2 and 3 and an amplifier 5 to the voltage frequency converter 9.

The movement direction change-over switch 13, and thus the contactor coil 16 or 17 selected by the latter, are both connected in series with a resistor 11 connected to the battery supply line 23.

The live end of the resistor 11 is connected via a line 29 and a limiting resistor 15 to the base of a control transistor 10 whose emitter is connected to the line 23, and whose collector is connected to the input end of an inverter 7 which is connected via a blocking diode 6 to a line 30, which line is connected from the junction of the resistors 2 and 3 to one electrode of a capacitor 4 whose other electrode is connected to the line 23. Via a resistor 31, the collector of the control transistor 10 is connected to the supply line 22, so that when the control transistor 10 is conductive, a current can flow from the line 22 to the line 23 via the resistor 31 and the transistor 10. This switching state exists whilst there is a voltage drop across the resistor 11, i.e. as long as current is flowing through one of the contactor coils, 16 or 17. A resultant "L" signal appears at the collector of the control transistor 10, and is inverted by the inverter 7 so that the latter's output rises to an "H" signal. The capacitor 4 is thus charged and the voltage frequency converter 9 is controlled from the speed controller generator 1, the elements 6, 7, 31 and 10 being of no effect in this condition.

If the movement direction change-over switch 13 is switched over, then im-

mediately one of the contacts is opened and the current flow through the resistor 11 is interrupted, the voltage drop across the resistor disappears, the control transistor 10 blocks, and thus its collector rises to the "H" signal level, which is inverted by the inverter 7, so that the diode 6 conducts and the capacitor 4 is discharged via the diode 6 and the inverter 7, which completes a discharge path. However, this causes the input signal for the voltage frequency converter 9 to be set to zero, and the pulse control unit is thus set at zero. If a suitable selection is made regarding the inertia of the electronic control unit on the one hand and the contactors on the other hand, it is possible to ensure that the motor current through the pulse control unit is set to zero, or at least substantially reduced, before the particular current-conducting contactor opens.

When the movement direction change-over switch 13 energises the other contactor coil 17 or 16, a voltage drop re-appears across the resistor 11, with the result that the control transistor 10 conducts again, the capacitor 4 is again charged, and following a delay time governed by this charging, the input signal can again pass from the speed controller generator 1 to the voltage frequency converter 9 in normal fashion.

The contactor coil 16 or 17 which has in each case been switched on via the movement direction change-over switch is connected in series with an interrupter transistor 12 which produces a function connection between the speed controller generator 1 for the pulse control unit and the degree of current flow through the selected contactor coil 16 or 17, in such manner that the pulse control unit does not start until the contactor is closed. For this purpose, a comparator 8 is connected between the input signal line 28 and the base of the interrupter transistor 12. There is also a logic-linking AND-gate 18 connected in the input signal path, which enables the connection of the contactor to be made dependent upon other conditions, for example, upon the signal of a thermal switch responsive to the motor temperature.

On a switch-over of the movement direction switch 13, the speed controller input signal is set to zero since the control transistor 10 blocks and the interrupted transistor 12 also blocks. As long as the transistor 12 is non-conductive no voltage drop can occur across the resistor 11, so that the control transistor 10 cannot be made conductive. If the speed control generator 1 emits a signal in this switching state, this signal is set to zero in the line 30 via the diode 6 and the inverter 7, but at the input end of the series resistor 2 a voltage builds up which, when it exceeds a predetermined value, passes via the comparator 8 to switch on the interrupter transistor 12. This causes a voltage drop to re-appear across the resistor 11, so that the control transistor 10 conducts again, and thus a speed control input signal can now be fed to the pulse control unit.

WHAT WE CLAIM IS:—

1. A d.c. motor control apparatus for an electrically propelled vehicle, comprising a speed controller for regulating the current supplied to the motor, first and second contactors respectively actuable, in use, to complete connections to the motor windings for rotation of the motor in first and second directions corresponding to forward and reverse motion of the vehicle, switching means selectively operable to pass an actuating current to one or other of the contactor coils, and disabling means including current sensing means connected in series with said switching means for sensing the flow of said actuating current, said disabling means being arranged to inhibit the supply of motor current by the speed controller when the actuating current is interrupted so that, in use, supply of the motor current is at least substantially reduced before opening of the motor circuit by the relevant contactor.

2. An apparatus as claimed in claim 1, in which said speed controller comprises a pulse control unit for supplying current to the electric motor.

3. An apparatus as claimed in claim 2, in which the current sensing means includes a current sensing resistor through which, in use, said actuating current passes and which is connected between the base and emitter of a control transistor whose collector is connected via a control path to the speed controller.

4. An apparatus as claimed in claim 3, in which the current sensing resistor is connected via a limiting resistor between the base and emitter of the control transistor.

5. An apparatus as claimed in claim 3 or 4, in which the speed controller has an input connectable to receive a control voltage from control means adjustable by the vehicle operator, and said control path includes an inverter and a series blocking diode connected between said inverter and said controller input.

6. An apparatus as claimed in claim 5, in which connected to said input is a capacitor across which, in use, said control voltage appears, and the diode is connected to provide a discharge path for said capacitor via said inverter when said control transistor is non-conductive.

7. An apparatus as claimed in any preceding claim, including a signal source con-

trollable by the vehicle operator to provide at an output thereof a variable control signal, the speed controller being connected to receive said control signal and arranged in operation to control the motor current in accordance with the control signal, and a semiconductor switching element connected in series with said switching means, and so controlled by the control signal that the switching element is non-conductive or conductive whenever the control signal is respectively below or above a predetermined level which corresponds to substantially zero drive by the speed controller.

8. An apparatus as claimed in claim 7, in which said semiconductor switching element is a transistor whose base is connected via a control path to the input signal line.

9. An apparatus as claimed in claim 8, in which a comparator is arranged in the path from the signal source output to the transistor.

10. An apparatus as claimed in claim 8 or claim 9, in which a logic linking gate is arranged in the path from the signal source output to the transistor.

11. An electric motor control apparatus substantially as described with reference to the accompanying drawing.

12. An electrically driven vehicle having an electric motor control circuit as claimed in any preceding claim.

13. A fork-lift truck in accordance with claim 12.

For the Applicants,
G. F. REDFERN & CO.
Marlborough Lodge
14 Farncombe Road
Worthing BN11 2BT

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd., Berwick-upon-Tweed, 1978.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

1 523 599 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.